ELEC 2607 Lab 1: Telephone Switch

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Lab #1

Lab Section: L9O [Monday 2:35-5:25]

Introduction:

This lab experiment consisted of constructing a telephone switch circuit which connected one of four callers to connect to one of eight listeners. The circuit was constructed on the Logic Lab trainer and only allowed for once conversation to take place at any one time. A scaled-up version of this system would be used for solicitation purposes but would include more switches connected in parallel to facilitate multiple conversations simultaneously.

A multiplexer (MUX) circuit and a demultiplexer (DeMUX) circuit were constructed using the basic logic gates present on the Logic Lab trainer. The MUX and the DeMUX circuits were then connected to form the telephone switch. The MUX takes one of multiple inputs to send to an output which in this experiment is the DeMUX. The DeMUX takes the input from the MUX and switches it between multiple outputs. The input and output of the telephone switch was selected using a binary signal which controlled the switch which connected the calling and the listening party. The circuit was constructed in three parts; the MUX, the DeMUX and the dialer circuit which connected the caller and listener. Each circuit was tested individually before the next circuit was built which made it easier to spot and rectify any errors made, as opposed to testing the entire circuit at once.

The following sections contain the circuit specifications and include details of the individual circuits. They also identify limitations with the design. Furthermore, the design process and methods used to satisfy the requirements are also described along with the testing methodology and any debugging steps taken.

Specifications:

The telephone switch circuit was designed with the limits of the Logic Lab trainer in mind as the Logic Lab trainer has a limited number of gates. The circuit design for the MUX and DeMUX had to be creative to make full use of the Logic Lab trainers limited number of OR and AND gates.

There are 4 callers (inputs W, X, Y and Z) and 8 listeners (outputs A, B, C, D, E, F, G and H). The MUX switch accepts a two-bit binary number that corresponds with a caller and the DeMUX switch accepts a three-bit binary number which corresponds with a listener. The four callers were connected to four switch outputs of the Logic Lab trainer and each input had its own switch which could be set to a 1 or 0.

Design:

The telephone switch consisted of three circuits, a 4 input MUX, an 8 output DeMUX and a dialer. The design of the dialer circuit was provided in the lab and was connected according to the instructions specified in the lab (Figure 1).

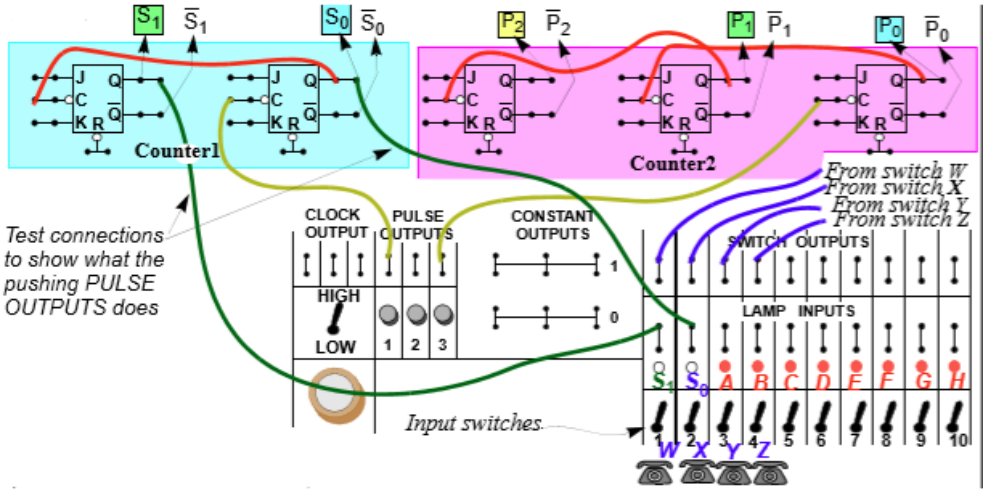

Figure 1: Pulse Circuit Design

A standard MUX circuit can only switch between 2 inputs (figure 2). The 4 input MUX circuit was designed by connecting two 2 input MUX circuits to a third 2 input MUX. Figure 3 shows a 4 input MUX built using the described design.

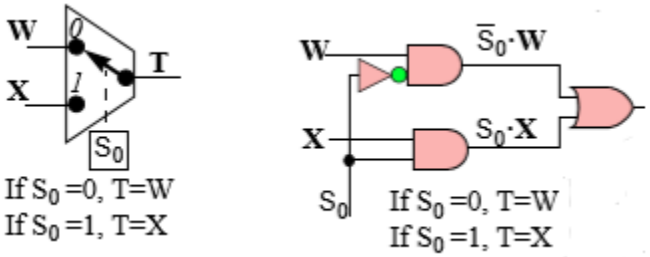

Figure 2:Standard 2 input MUX with schematic

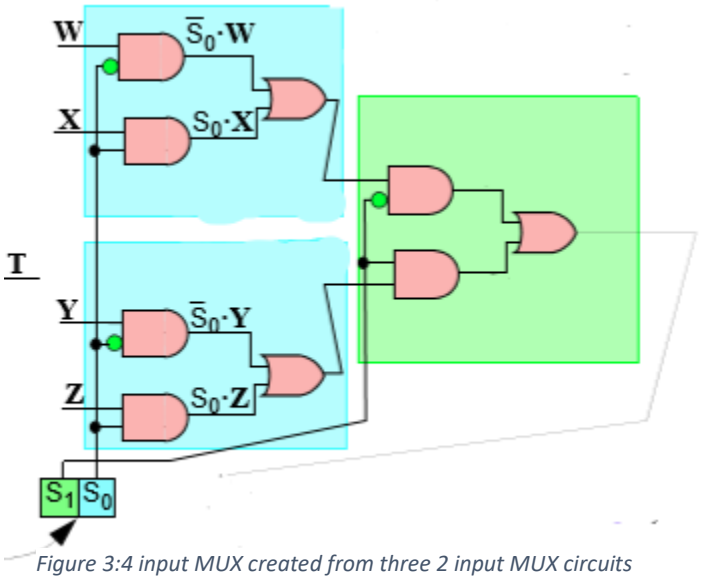

Figure 3:4 input MUX created from three 2 input MUX circuits

Other designs are feasible for a MUX circuit, but the design seen in figure 3 was used since it utilizes the dual 2 input AND-NOR gates which reduce the number of gates otherwise required which is beneficial when working with the limitations of the Logic Lab. The design turns the dual input AND-NOR gate into a MUX circuit by connecting an inverter to the NOR gate which reduces the number of wires needed while leaving other gates on the logic lab free.

The final component of the circuit was the 8 input DeMUX circuit. The design of the DeMUX is like that of the MUX circuit. Three 2 output DeMUXs were connected as seen in figure 5 to make a 4 output DeMUX.

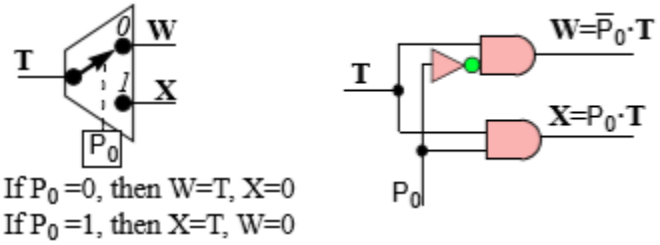

Figure 4:Standard 2 output DeMUX and schematic

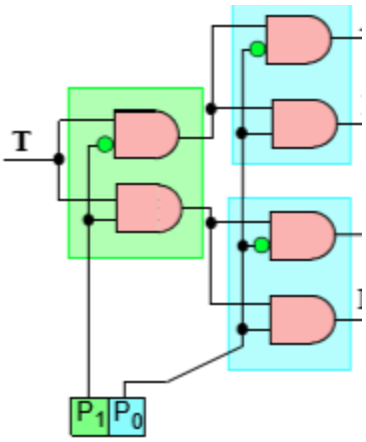

Figure 5:4 output DeMUX circuit made from three 2 output DeMUX circuits

The design in figure 4 was unfeasible due to the Logic Lab trainer lacking the number of AND gates required to complete it. The design was therefore modified into the one seen in figure 6, which uses 2 NAND and 4 NOR gates instead of the 6 AND gates required by the design shown in figure 5.

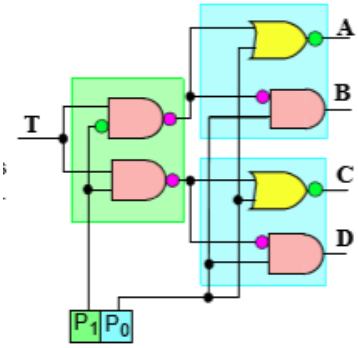

Figure 6:Modified 4 output DeMUX circuit

The 8 output DeMUX circuit was made by connecting two 4 output DeMUX circuits to the outputs of one 2 output DeMUX circuit as seen in figure 7.

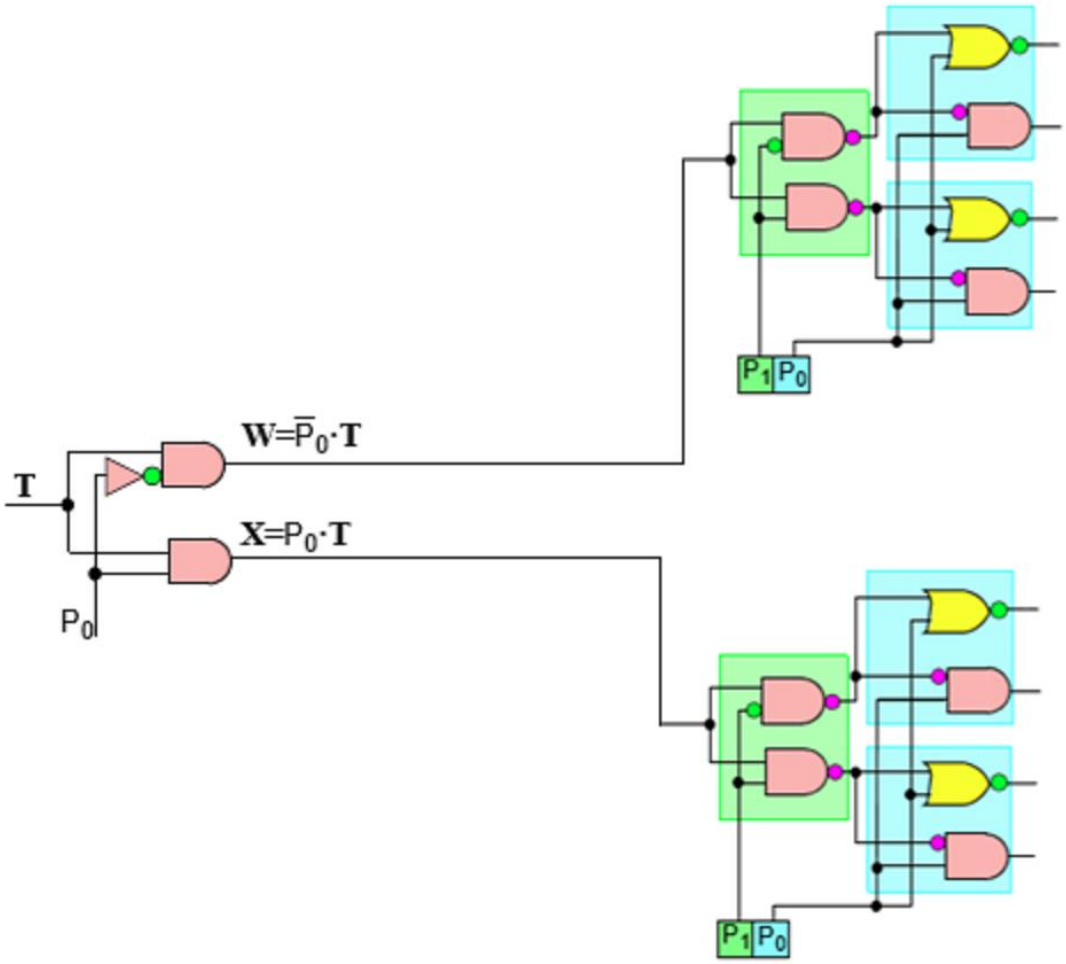

Figure 7: 8 output DeMUX circuit made from two 4 output DeMUXs and one 2 output DeMUX

The MUX and DeMUX circuits are connected using the trunk line to complete the final telephone circuit. Refer to figure 8 for the final design of the telephone switch

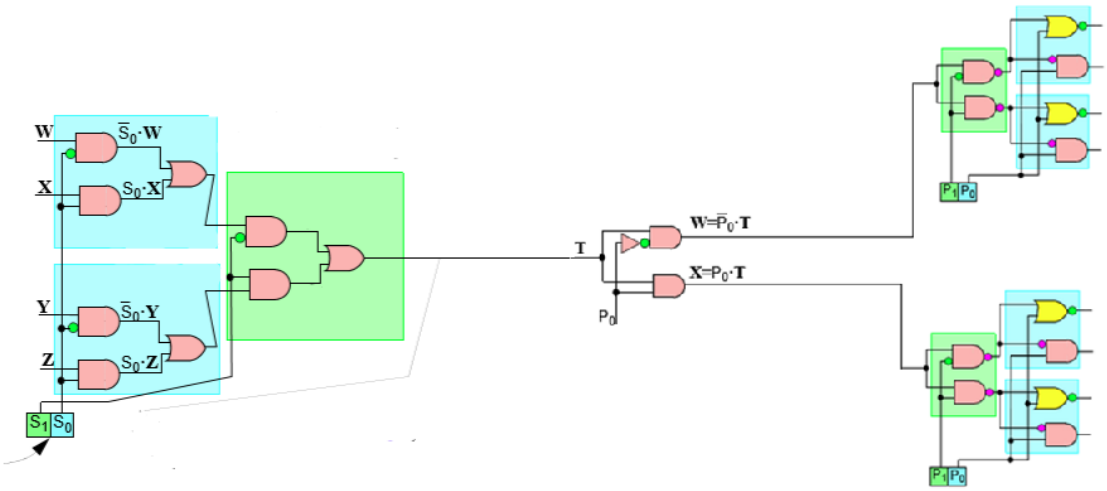

Figure 8:Final Telephone Switch

Implementation and Testing:

The telephone switch consisted of one 4 input MUX made from three 2 input MUX circuits, one 8 output DeMUX circuit made from one 2 output DeMUX circuit and two 4 output DeMUX circuits and a pulse dialer circuit which selects the caller and listener. Below is a breakdown of the individual gates used to construct the MUX and DeMUX.

The 2 input MUX consists of:

- Two 2 input AND gates
- One 2 input NOR gate
- One inverter
- A control signal S_0

The 2 output DeMUX consists of:

- Two 2 input AND gates
- One inverter
- A control signal P_2

The 4 output DeMUX consists of:

- Two 2 input NAND gates
- Four 2 input NOR gates
- Two control signals P_1 and P_0

The circuit was tested by connecting the inputs of the MUX to the switch outputs of the Logic Lab trainer. The outputs of the DeMUX were connected to the lamp inputs of the Logic Lab

trainer. The caller and listener are selected using the pulse dialer which uses the pulse output button of the Logic Lab trainer. The input switch corresponding with the caller is set to 1. If the circuit functions properly, the lamp corresponding with the caller lights up. This means that the caller and listener are connected successfully. If the circuit is connected improperly, the light would not turn on, or the wrong light would turn on if there was a wiring mix-up.

While testing, it was observed that the 2-bit binary number 10 would not trigger the light outputs correctly. This was rectified by tightening the S_0 connection for input W. Upon retesting, the MUX circuit worked correctly.

The DeMUX circuit had a wiring error which resulted in no output and in the process of rectifying it, some wires for the MUX circuit were accidentally pulled out rendering the MUX inoperative. The circuits were not rebuilt due to a lack of time in the lab period.

Conclusion:

The lab was easy to prepare for, however there was a lack of long wires which caused some problems. The larger problem was that the Logic Lab trainer was overcrowded with wires once all three circuits were in place and made it extremely difficult to debug and made it easier for accidents to occur. More long wires should be provided, so that gates further apart are easier to connect. This change would make this lab better in the future.